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(54) **Title:** TRIPLE LAYER ANTI-REFLECTIVE COATING FOR A TOUCH SCREEN

(57) **Abstract:** A touch screen includes a triple layer anti-reflective coating (ARC). The touch screen can be an analog or a matrix resistive touch screen. The anti-reflective coating includes two high index layers and a low index layer. The exposed high index layer is conductive. The anti-reflective coating can be provided on one or both of a flex layer and a stable layer.

TRIPLE LAYER ANTI-REFLECTIVE COATING FOR A TOUCH SCREEN

FIELD OF THE INVENTION

The present invention relates to touch sensors or touch screens. More particularly, the present invention relates to anti-reflective coatings for touch sensors or touch screens.

BACKGROUND OF THE INVENTION

Generally, touch sensors or touch screens, such as, capacitive or resistive touch screens, are utilized in front of a computer driven display capable of variable images or in front of a non-variable display capable of providing fixed images. The touch sensor or touch screen provides an interface so that a human can provide commands to a computer or other control device. Touch screens can be utilized with computers, control panels, controllers, pocket organizers (Palm Pilot® organizer), arcade games, or any electronic device requiring human interaction. Generally, the touch screen is placed above (in front of) the display and includes at least one conductive layer which is utilized to sense the presence and location of a touch.

As an example of one type of touch screen, a conventional resistive touch screen includes two layers which are often referred to as, a flex layer and a stable layer. Both the flex layer and the stable layer have transparent, conductive coatings on opposing surfaces. The flex layer and the stable layer are separated from each other by an air gap or other non-conductive medium.

When the outer front surface of the touch screen is pressed, the two transparent, conductive coatings are brought into electrical contact. More specifically, the flex layer is deformed and the conductive coating on the flex layer contacts the conductive coating on the stable layer. Typically, the stable layer is not flexible. Conventional resistive touch screens include matrix touch screens and analog touch screens.

Matrix touch screens generally have transparent conductive coatings patterned in rows on one surface (the flex layer) and in columns (orthogonal to the rows) on the opposing surface (the stable layer). When force is applied and electrical contact is made as described above, a discrete switch is closed. The discrete switch is associated with a particular row and column. A computer or other electronic circuit can be utilized to provide electric signals to the rows and columns and determine the horizontal and vertical position (X, Y coordinate) associated with the discrete switch which is closed.

In analog resistive touch screens, the transparent, conductive surfaces are provided on the flex and stable layers. The conductive coatings have uniform sheet resistivity. The sheet resistivity used in analog resistive touch screens is typically between 100 and 1000 Ohms/square, with 200 to 400 Ohms/square being a preferred resistivity.

A voltage is applied to one end of one of the transparent, conductive (resistive) layers through a conductive bus bar, while the other end of the same layer is held at ground, to produce a linear voltage gradient across the screen. The bus bars are configured to create a horizontal voltage gradient on one screen and a vertical voltage gradient on the other screen. When a force, such as, by a finger or stylus, is applied to the flex layer, the flex layer electrically contacts the stable layer and the switch is closed. With the switch closed, one floating layer is used to receive the voltage created by the gradient on the other layer at the point of contact. The role of each layer is then reversed and the voltage is measured on the other layer. The analog resistive touch screen is connected to a computer or electronic circuit which decodes the voltages and converts it to a position associated with the touch. Two voltage readings are used to assign a horizontal and vertical (X, Y coordinate) position for the location of the touch. Points can be recorded electronically fast enough that signatures can be digitized and recorded.

It is generally desirable to maximize the optical transmission through the touch screen across the entire visible spectrum. Optical transmission of light

through the touch screen is adversely affected if light is absorbed or reflected as it is transmitted through the touch screen. The amount of light reflected at any interface between two materials depends upon the refractive indices and thicknesses of the two materials on either side of the interface. The amount of reflection is proportional to the difference between refractive indices (the larger the difference in the refractive index, the greater the amount of light is reflected). Light that is reflected is not transmitted through the touch screen.

Generally, the conductive coatings associated with the flex layer and stable layer of the touch screen have a refractive index which is typically 1.8 to 2.2. Air associated with the air gap between the conductive coatings has a refractive index which is 1.0.

The large difference in refractive indexes associated with the conductive coating and air gap interfaces is the greatest difference in refractive indexes in the entire resistive touch screen construction. Accordingly, the conductive coating and air gap interfaces cause the greatest amount of light reflection. Thus, it is desirable to reduce the amount of reflection associated with the conductive coating and air gap interfaces.

Anti-reflective coatings generally use alternating layers of transparent materials having low and high or high and low refractive indexes on a substrate. The indexes are chosen so that the index and thickness of the layers results in destructive interference between the light reflected off the first and second layers. The total amount of light reflected can be minimized if the optical thickness is designed for maximum destructive interference of reflected light.

Conventional touch screen systems have utilized a two layer anti-reflective coating to reduce reflection at the conductive coating and air gap interface. The two layer anti-reflective coating is applied to the substrate of the flex layer. The two layer anti-reflective coating includes a silicon dioxide layer above the substrate and a conductive coating above the silicon dioxide layer. The

conductive coating above the silicon dioxide layer is utilized to sense the touch as described above.

Thus, there is a need for maximizing the amount of transmission through a touch screen. Further, there is a need for a touch screen which provides superior transmission than a touch screen utilizing a two layer anti-reflective coating.

SUMMARY OF THE INVENTION

One exemplary embodiment is related to an anti-reflective coating for a touch screen. The touch screen includes translucent material. The touch screen allows viewing through the translucent material. The translucent material has an exterior side closer to an exterior of a touch screen and an interior side closer to an interior of the touch screen. The anti-reflective coating includes a first layer, a second layer and a third layer. The first layer is disposed adjacent the interior side of the translucent material. The first layer has a high refractive index. The second layer has a low refractive index and is disposed adjacent the first layer. The third layer is disposed adjacent the second layer and is closer to the second layer than the first layer. The third layer is conductive and is utilized to sense touches on the touch screen. The anti-reflective coating reduces reflection at the interior air interface.

Another exemplary embodiment relates to a touch screen layer including a polyester film. The touch screen allows viewing through the polyester film layer. The polyester film has an exterior side farther from a touch and an interior side closer to the touch. The touch screen also includes an anti-reflective coating means for increasing transmission through the polyester film. The anti-reflective coating means includes a first layer disposed adjacent the interior side, a second layer disposed adjacent the first layer, and a third layer disposed adjacent the

second layer. The third layer is closer to the second layer than the first layer. The third layer is conductive.

Another exemplary embodiment of the present invention relates to a method of manufacturing a touch screen. The touch screen includes a translucent material. The touch screen provides visual indicia through the translucent material. The translucent material has an exterior side closer to an exterior of the touch screen and an interior side closer to an interior of the touch screen. The method includes providing a first layer adjacent the interior side of the translucent material, providing a second layer adjacent the second layer, and providing a third layer adjacent the second layer. The first layer has a high refractive index, and the second layer has a low refractive index. The third layer is closer to the second layer than the first layer. The third layer is conductive and is adjacent an air gap. The first, second and third layers reduce reflection at the interior air interface.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments will be described hereinafter with reference to the accompanying drawings, wherein like numerals denote like elements, and:

FIGURE 1 is an exploded isometric view of a touch screen;

FIGURE 2 is an elevation side view of the touch screen illustrated in FIGURE 1;

FIGURE 3 is a cross-sectional view of the touch screen illustrated in FIGURE 1 showing two triple layer anti-reflective coatings; and

FIGURE 4 is a more detailed cross sectional view of one of the triple layer anti-reflective coatings illustrated in FIGURE 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to Figures 1 and 2, a touch screen 10 is embodied as a Dynaclear™ 4-wire analog resistive touch panel. Alternatively, screen 10 can be a

matrix touch screen, or other type of apparatus for sensing touches. Touch screen 10 includes a flex layer 20, a spacer 30, and a stable layer 40.

Flex layer 20 and stable layer 40 are preferably opposing substrates separated by an air gap 32 (Figure 1). Gap 32 is necessary to allow contact between the conductive coatings on surfaces 21 and 41 and yet insulate surfaces 21 and 41 from each other. Layers 20 and 40 each advantageously include a triple layer anti-reflective coating (See Figures 3 and 4) on interior surfaces 21 and 41, respectively. Layer 20 includes an exterior surface 22, and layer 40 includes an exterior surface 42. Layer 20 includes a set of conductive bus bars 24, and layer 40 includes a set of conductive bus bars 44.

Screen 10 senses the existence and location of a touch on surface 22. Exterior surface 22 is closer to the touch than interior surface 21. Spacer 30 is insulative and provides air gap 32 between layer 20 and layer 40. Layer 20 is deformed to contact layer 40 across air gap 32. When layer 20 contacts layer 40, the touch from a finger or stylus can be sensed. Generally, the touch is sensed when conductive surface 21 contacts conductive surface 41.

Bus bars 24 and 44 can be silver ink typically having a conductivity 1000 times more conductive than surfaces 21 and 41. Generally, surfaces 21 and 41 include an indium tin oxide (ITO) film having a resistivity of 100-1000 Ohms/square. Preferably, surfaces 21 and 41 have a resistivity of 200-400 Ohms/square. The film is typically deposited by a sputtering technique.

Layers 20 and 40 are typically a thin translucent substrate, such as glass or polyester. As used in this application, the term translucent means allowing at least some or all light to pass. A translucent material includes all materials which are transparent and/or non-opaque. Preferably, layers 20 and 40 are manufactured from a polyester (PET) film which is .005 to .007 inches thick. Layers 20 and 40 include triple layer anti-reflective coatings including the thin ITO film on surfaces 21 and 41, respectively.

Images are provided through touch screen 10. Sources for such images can be, cathode ray tubes (CRTs), liquid crystal displays (LCDs), plasma displays, EL displays, books, pictures, or other sources of information. Touch screen 10 can include an inlay which provides visual indicia or can include a screen capable of providing variable visual indicia. Thus, images can be seen through layers 20 and 40 associated with screen 10.

With reference to Figure 3, screen 10 includes a triple layer anti-reflective coating 52 associated with surface 21 of layer 20 and a triple layer anti-reflective coating 54 associated with surface 41 of layer 40. Alternatively, screen 10 can have a triple layer anti-reflective coating either only on layer 20 or layer 40. Layers 20 and 40 are a composite of transparent layers through which light is transmitted. For example, light from visual indicia 47 can be provided through layers 20 and 40.

Layer 20 includes a hard coating layer 56, a substrate 60 and coating 52. Similarly, layer 40 includes a substrate 70 and coating 54. Substrates 60 and 70 are a translucent material, such as, glass, plastic, or PET.

Layer 56 is associated with surface 22 of layer 20. Preferably, layer 56 is an ultraviolet light cured acrylate which provides a hard coating and is 0.0001 to 0.0015 inches thick. Layer 56 can have a roughened surface to decrease reflective glare off surface 22 and to reduce the visibility of finger prints on surface 22. The roughened surface of layer 56 can be produced by a filler material, such as, silica particles.

Surface 21 generally does not include a hard coating layer such as layer 56. Surface 21 can include a textured coating, such as, acrylic or other clear polymer coating filled with glass or plastic spheres to prevent Newton rings in the final touch screen construction.

Layer 20 is built on a PET layer or substrate 60. Anti-reflective coating 52 includes a layer 62, a layer 64 and a layer 66. Layer 62 can be provided

directly on substrate 60 or on the Newton ring coating upon layer 60. Layer 62 can be a high index translucent material, such as, indium tin oxide (ITO), tin antimony oxide, tin oxide or yttrium oxide provided on surface 21. Layer 62 can be a conductive or non-conductive layer.

Layer 64 is a layer of silicon dioxide. Layer 66 is a layer of ITO and serves as the layer which provides the electrical contact between layers 20 and 40 when a touch is sensed.

Similar to anti-reflective coating 52, anti-reflective coating 54 is disposed on a PET layer or substrate 70. Anti-reflective coating 54 is comprised of layer 62, layer 64 and layer 66. Layers 62, 64 and 66 of coating 54 are similar to layers 62, 64 and 66 of coating 52.

With reference to Figure 4, anti-reflective coating 52 is described. However, description of anti-reflective coating 52 is applicable to anti-reflective coating 54. Although specific materials and thicknesses are given, the details disclosed are examples only. Layers 62, 64 and 66 can be applied to substrate 60 by sputtering or evaporation deposition technique.

Layer 62 is preferably a film or coating having a high index of refraction such as between 1.8 and 2.9. Layer 62 can be indium tin oxide (ITO). Alternatively, layer 62 can be manufactured from other materials having a high index of refraction including, but not limited to, tin oxide, zirconium oxide, yttrium oxide, titanium oxide, and niobium oxide. Thicknesses for layer 62 can range from 10-100 nm depending upon the type of material used.

Layer 64 preferably has a low index of refraction, such as, between 1.4 and 1.6 and is an insulative material. Preferably, layer 64 is silicon dioxide which has a thickness of 15 to 60 nm. Alternatively, layer 64 can have a thickness which ranges from 10 to 100 nm.

Layer 66 is preferably a film or coating of conductive material. Layer 66 can be ITO, although other conductive materials can be utilized. Layer 66

can be similar to layer 62. Layer 66 preferably has a high index of refraction between 1.8 and 2.2. Layer 66 is preferably 20 to 30 nm thick. Alternatively, layer 66 can be from 10-100 nm thick.

In one preferred embodiment, layer 66 is 25 nm thick, layer 64 is 45 nm thick, and layer 62 is 70 nm thick. In another embodiment, layer 66 is 30 nm thick, layer 64 is 39 nm thick, and layer 62 is 78 nm thick. Alternatively, the ranges and thickness for layers 62, 64, and 66 can be from 10 to 100 nm for each layer. In addition, anti-reflective coating 52 can include more than triple layers, although adding additional layers adds to the cost of coating 52.

Conventional touch screens 10 which do not include coatings 62 and 64 generally reflect approximately 8% of the light from each ITO to air interface. Although conventional reflective coatings can reduce this reflection to 4 to 6%, anti-reflective coatings 62 and 64 can further reduce this reflection to 1.5 to 2.5%. This is a considerable gain from conventional anti-reflective coatings and an even further gain from touch screen which have no anti-reflective coating whatsoever.

It is understood, that while preferred exemplary embodiments of the present invention are given, they are for purpose of illustration only. The apparatus and method of the invention are not limited to the precise details, geometry, dimensions, materials and conditions disclosed. Various changes can be made to the precise details discussed without departing from the spirit of the invention which is defined by the following claims.

WHAT IS CLAIMED IS:

1. An anti-reflective coating for a touch screen, the touch screen including a translucent material, wherein the touch screen provides visual indicia through the translucent material, the translucent material having an exterior side closer to an exterior of the touch screen and an interior side closer to an interior of the touch screen, the anti-reflective coating comprising:

a first layer disposed adjacent the interior side of the translucent material, the first layer having a high refractive index;

a second layer adjacent the first layer, the second layer having a low refractive index; and

a third layer adjacent the second layer, the third layer having a high refractive index, wherein the third layer is closer to the second layer than the first layer, wherein the third layer is conductive and is utilized to sense touches on the touch screen, whereby the anti-reflective coating reduces reflection at the interior air interface associated with the touch screen.

2. The anti-reflective coating of claim 1, wherein the first layer has a refractive index of 1.7-2.9 and the second layer has a refractive index of 1.4-1.6.

3. The anti-reflective coating of claim 2, wherein the third layer has a refractive index of 1.8-2.2.

4. The anti-reflective coating of claim 1, wherein the first layer is a conductive layer.

5. The anti-reflective coating of claim 1, wherein the second layer is silicon dioxide and the third layer is indium tin oxide.

6. The anti-reflective coating of claim 1, wherein the first layer, the second layer and the third layer have a thickness between 10 and 100 nanometers.

7. The anti-reflective coating of claim 1, wherein the first layer is

attached to the second layer and the second layer is attached to the third layer..

8. The anti-reflective coating of claim 6, wherein the second layer is between 15 and 60 nanometers thick.

9. The anti-reflective coating of claim 1, wherein the reflection at the interior air interface associated with the touch screen is reduced from approximately 8 percent to less than approximately 2.5 percent by the first, second and third layers.

10. A touch screen, comprising:

a polyester film, wherein the touch screen provides visual indicia through the polyester film, the polyester film having an exterior side closer to a touch and farther from the touch; and

an anti-reflective coating means for increasing transmission through the polyester film, the anti-reflective coating means including a first layer disposed adjacent the interior side, a second layer adjacent the first layer, and a third layer adjacent the second layer, wherein the third layer is closer to the second layer than the first layer, wherein the third layer is conductive.

11. The touch screen of claim 10, wherein the first layer has a refractive index of 1.7-2.9 and the second layer has a refractive index of 1.4-1.6.

12. The touch screen of claim 10, wherein the third layer is utilized to sense the touch.

13. The touch screen of claim 12, wherein the first layer is a conductive layer.

14. The touch screen of claim 10, wherein the second layer is silicon dioxide and the third layer is indium tin oxide.

15. The touch screen of claim 14, wherein the first layer, the second

layer and the third layer have a thickness between 10 and 100 nanometers.

16. A method of manufacturing a touch screen, the touch screen including a translucent material, wherein the touch screen provides visual indicia through the translucent material, the translucent material having an exterior side closer to an exterior of the touch screen and an interior side closer to an interior of the touch screen, the method comprising:

providing a first layer adjacent the interior side of the translucent material, the first layer having a high refractive index;

providing a second layer adjacent the first layer, the second layer having a low refractive index; and

providing a third layer adjacent the second layer, the third layer having a high refractive index, wherein the third layer is closer to the second layer than the first layer, wherein the third layer is conductive and is adjacent an air gap, whereby the anti-reflective coating reduces reflection at the interior air interference associated with the touch screen.

17. The method of claim 16, wherein the first layer is applied to the translucent material, the translucent material being a polyester film.

18. The method of claim 16, wherein the second layer is applied to the first layer.

19. The method of claim 16, wherein the third layer is applied to the second layer.

20. The method of claim 16 wherein the first and third layers are indium tin oxide.

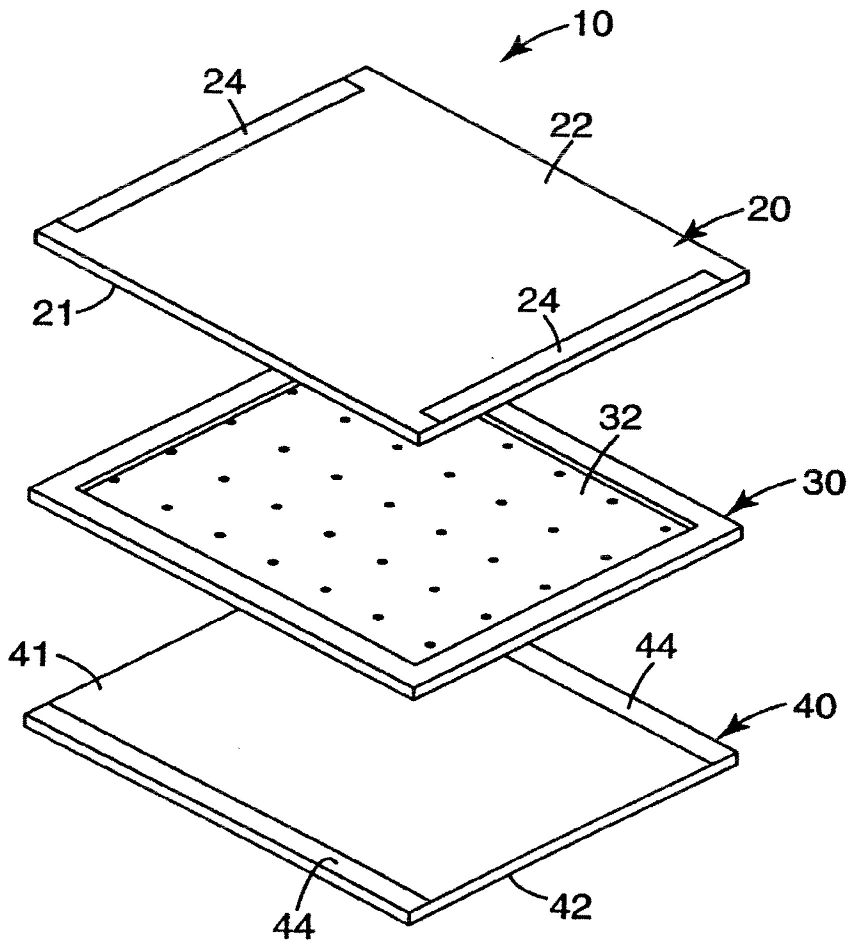


Fig. 1

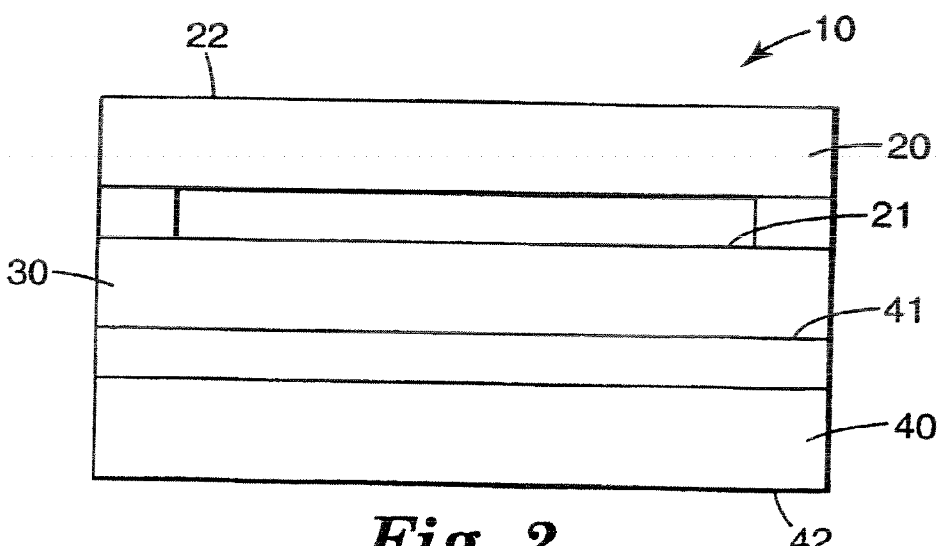
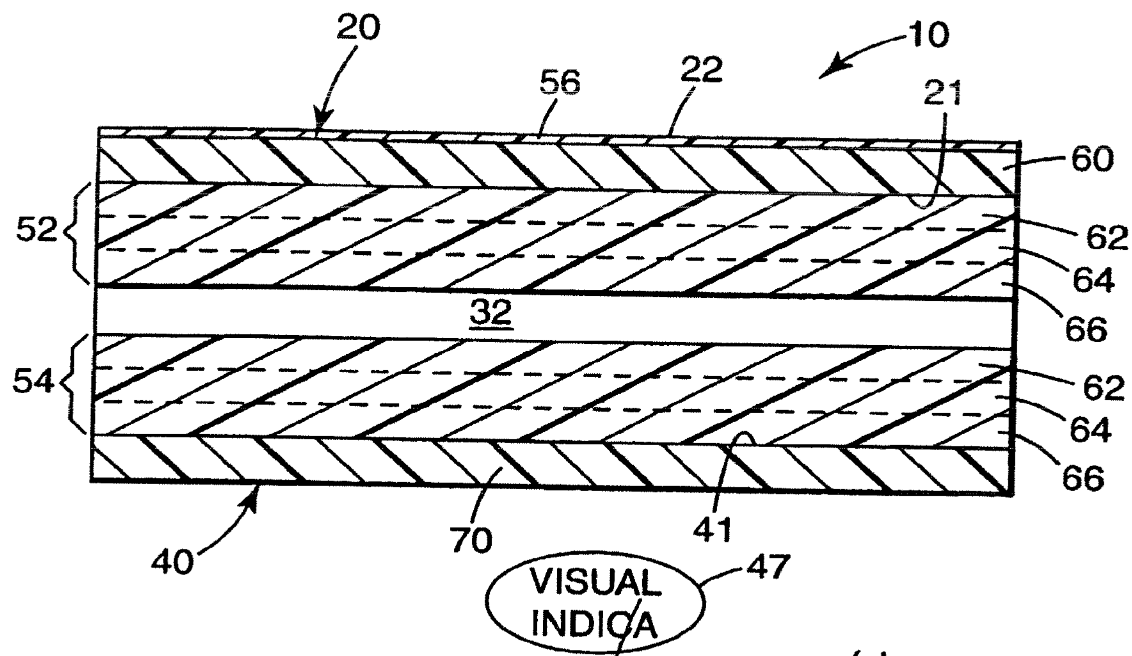


Fig. 2


20
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VISUAL
INDICA

Fig. 3

/i

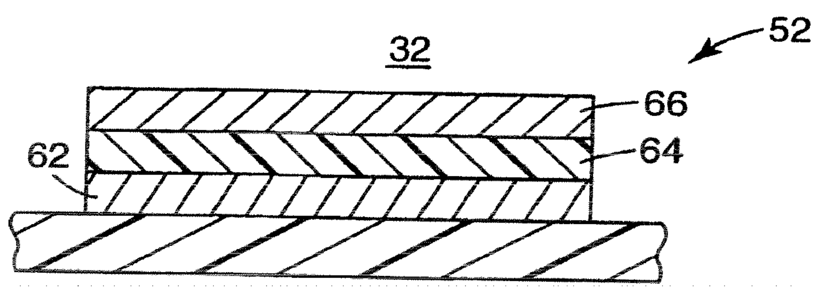
52
32
66
62
64

Fig. 4